INDOOR AIR QUALITY ASSESSMENT

Leominster City Hall
25 Water Street
Leominster, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality Program
October 2006

Background/Introduction

At the request of Christopher Knute, Director of the Leominster Health Department, an indoor air quality assessment was conducted at the Leominster City Hall (LCH), 25 Water Street, Leominster, Massachusetts. The assessment was conducted by the Massachusetts Department of Public Health (MDPH), Center for Environmental Health (CEH). On April 21, 2006, Michael Feeney, Director of CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program, made a visit to this building.

The LCH is a two-story, brick building with an occupied basement constructed in 1915. The interior of the building was renovated in the 1970s, which created offices in the basement and installation of a heating, ventilation and air-conditioning system. Windows in the building are openable.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

The building has an employee population of 25 and can be visited by several hundred members of the public daily. The tests were taken under normal operating conditions. Test results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that the carbon dioxide levels were below 800 parts per million (ppm) of air in the majority of areas surveyed indicating adequate air exchange. The exception was in the Health Department offices located in the basement, which had carbon dioxide levels above 800 ppm, indicating poor air exchange. Please note that many offices were not occupied during the assessment, which can greatly reduce carbon dioxide. Carbon dioxide levels would be expected to be higher with increased occupancy.

Mechanical ventilation in office space is provided by ceiling or floor-mounted fan coil units (FCUs) (Picture 1). However, the FCUs do not draw fresh air from outdoors through an air intake, rather they recirculate existing air. The sole source of fresh air is via opening windows. The use of the windows in basement office at the front of the building is limited due to reports of vehicle exhaust from traffic near the building. During the visit, FCUs were found deactivated throughout the building. The operation of FCUs will aid in air movement, which may increase comfort in basement offices.

The building was originally designed to use openable windows to create cross-ventilation to provide comfort for building occupants using windows on opposing exterior walls. In addition, the building has hinged windows located above the hallway doors. The hinged window (called a transom) (Picture 2) enables occupants to close hallway doors while maintaining a pathway for airflow into the room. This design allows for airflow to enter an open window, pass through a room, pass through the open transom, enter the hallway, pass through the opposing open room transom, into the opposing room and exit the building on the leeward side (opposite the windward side) (Figure 1). With all windows and transoms open, airflow can be maintained in a building regardless of the direction of the wind. This system fails if the windows or transoms are closed (Figure 2). Most transoms were closed and rendered redundant since the FCUs also provide cooling during summer months.

Large meeting areas are equipped with ceiling or wall mounted fresh air diffusers and return vents connected to air handling units (AHUs) with fresh air intakes and exhausts, located in the boiler room. Of note is the fresh air supply ductwork above the ceiling in the City Council Meeting room, which has a large breach, allowing air to escape and pressurize the ceiling plenum above the room (Picture 3). Airflow in the ceiling plenum would disturb dust and dirt and have the potential to migrate into the room through the ceiling system.

The Massachusetts Building Code requires a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information on carbon dioxide see Appendix A.

Temperature readings ranged from 69º F to 75º F, which were within or very close to the lower end of the MDPH recommended comfort range the day of the assessment. The MDPH recommends that indoor air temperatures be maintained in a range of 70º F to 78º F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measured in the building ranged from 26 to 36 percent, which was below the MDPH recommended comfort range on the day of the assessment. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. It is important to note however, that relative humidity measured indoors exceeded outdoor measurements (range +3 to 13 percent). Without the aid of mechanical ventilation or dehumidification, moisture removal is difficult. Moisture removal is important since the sensation of heat increases as relative humidity increases (the relationship between temperature and relative humidity is called the heat index). If moisture is removed, the comfort of the individuals is increased. Removal of moisture from the air, however, can have some negative effects. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Building occupants reported odors from the elevator carpet. Sometime after the 1970s renovation, an elevator was added to the west wall of the LCH. A room containing the elevator motor was constructed on the basement level, with a passive vent installed in the exterior wall of the building (Picture 4). A corresponding vent exists in the elevator shaft wall (Picture 5). The purpose of these vents is to equalize air pressure in the elevator shaft as the car moves. Since this room is open to the outdoors, the room and elevator shaft likely becomes extremely cold in the winter, as confirmed by employees in the office that contains the elevator room entrance. Cold air would then be drawn into the elevator shaft. Under these circumstances the elevator car floor can be prone to condensation.

If cold air penetrates into the elevator shaft, it may come in contact with warm building materials (e.g., elevator shaft), and result in condensation. Condensation is the collection of moisture on a surface that has a temperature below the dew point. The dew point is a temperature that is determined by air temperature and relative humidity. As an example, at a temperature of 70^{o} F and relative humidity of 25 percent indoors, the dew point for water to collect on a surface is approximately 32^{o} F (IICR, 2000). Therefore, any surface that has a temperature below 32^{o} F (e.g., elevator room and likely the floor of the elevator car) would be prone to condensation generation under these temperature and relative humidity conditions. Therefore, the carpet can become repeatedly moistened, which can subsequently lead to mold growth and/or associated odors.

It appears that the designer of the elevator system was concerned with the possibility of cold air affecting the elevator motor and condensation, since an electric baseboard heater was installed in the elevator room. The heater should be activated during cold weather to heat the room and decrease condensation. In addition, a sump pump exists in the floor of the elevator room (Picture 6). The cover for the pump was off, exposing the sump pump which had standing water in it. The cover should be replaced to minimize the drawing of odors into the elevator/shaft.

Some areas had water-damaged ceiling tiles which can indicate leaks through window frames (Table 1). Water-damaged ceiling tiles can provide a medium for mold and growth and should be replaced after a water leak is discovered and repaired.

A restroom in the basement had mold colonized pipe insulation (Picture 7). This condition may indicate that the restroom does not have adequate exhaust ventilation to remove water vapor. Another restroom in the basement had a disconnected flexible duct, allowing for restroom odors and water vapor to vent into the ceiling plenum (Picture 8). Restroom vents should vent directly outdoors.

The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. Water-damaged porous materials (e.g., ceiling tiles, carpeting, insulation) cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy porous materials is not recommended.

During the assessment, BOH staff indicated that mold odors existed in the office space beneath the front of the LCH. A bookcase with a pungent mold odor was identified by CEH staff as the likely source. The book case was removed the day of the visit, eliminating the musty odor.

Several rooms also had a number of plants. Plant soil and drip pans can serve as source of mold growth. A number of these plants did not have drip pans or were in outdoor type planters with no drainage. The lack of drip pans and drainage can lead to water pooling and mold growth on windowsills when used indoors. Wooden sills can be potentially colonized by mold growth and serve as a source of mold odor. Plants should also be located away from FCUs to prevent the aerosolization of dirt, pollen or mold.

Other Concerns

FCUs are normally equipped with filters that strain particulates from airflow. Filters found inside the FCUs were not of sufficient size (Picture 9). With smaller filters, particulates/debris can be drawn into and accumulate inside the FCUs. Accumulated debris inside the FCU can obstruct airflow and may serve as a reservoir of particulates that can be re-aerosolized and distributed to occupied areas. In order to decrease aerosolized particulates, properly-sized, disposable filters with an adequate dust spot efficiency should be installed. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent would be sufficient to reduce airborne particulates (Thornburg, 2000; MEHRC, 1997; ASHRAE, 1992). Note that increasing filtration can reduce airflow, a condition known as pressure drop, which can reduce efficiency due to increased resistance. Prior to any increase of filtration, a ventilation engineer should be consulted as to whether the FCUs can maintain function with more efficient filters.

A number of areas contained window-mounted air conditioners. This equipment is also typically equipped with filters, which should be cleaned or changed per the manufacturer's instructions to avoid the build up and re-aerosolization of dirt, dust and particulate matter.

Finally scented candles were observed in work areas. Scents and burning candles can produce aerosolized particulates and odors that can be irritating to the eyes, nose and throat.

Conclusions/Recommendations

In view of the findings at the time of this visit, the following recommendations are made:

1. Ensure FCUs are activated during business hours year round. This will help to increase air circulation, particularly in the Health Department offices.

2. Remove carpet from elevator floor. Replace with a non-porous material (e.g., tile) to limit possible mold growth.

3. Replace cover on sump pump in elevator room. Install a hose in the cover to draw air from outdoors when the pump operates. Render the sump pump cover airtight with a sealant compound.

4. Use the heater in the elevator room during cold weather to prevent/limit condensation.

5. Seal the breach in the fresh air supply ductwork above the City Council Meeting Room.

6. Ensure that all FCUs have filters of sufficient size.

7. Service FCUs on a regular basis. This includes changing filters and cleaning drip pans.

8. Replace mold colonized pipe insulation in basement restroom. This material should be examined by a licensed asbestos inspector to ensure that remediation does not create an asbestos hazard.

9. Replace water damaged ceiling tiles. Identify source of water causing water damaged ceiling tiles (e.g., window frames) and make repairs as needed. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.

10. Ensure plants have drip pans and avoid over-watering. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary.

11. Avoid using candles in the building.

12. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
13. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. Materials are available on the MDPH's website: http://mass.gov/dph/indoor_air.

References

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BOCA. 1993. The BOCA National Mechanical Code-1993. 8^{th} ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL. M-308.1

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OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R. 1910.1000 Table Z-1-A.

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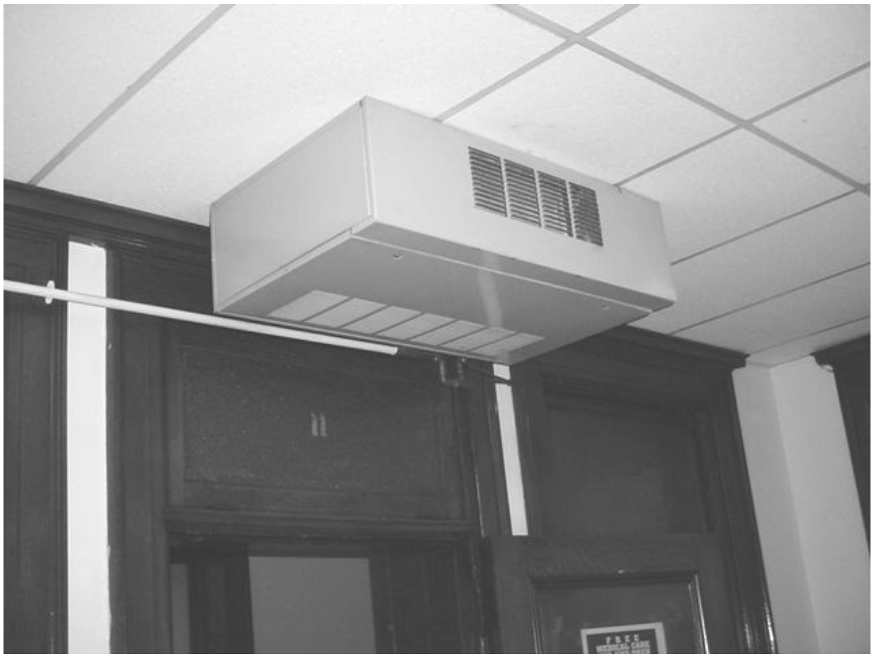
Thornburg, D. 2000. Filter Selection: a Standard Solution. *Engineering Systems* 17:6 pp. 74-80.

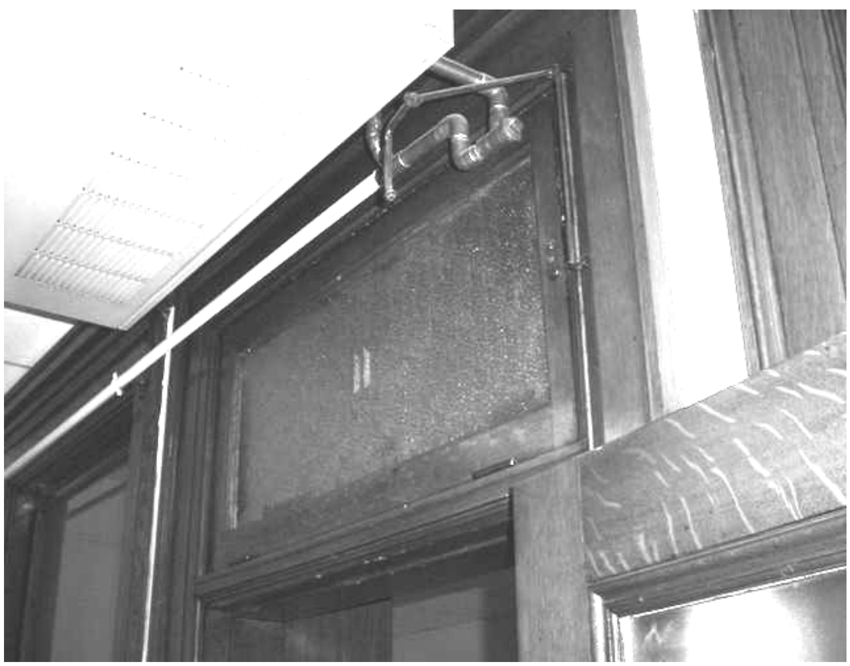
US EPA. 2001. Mold Remediation in Schools and Commercial Buildings. US Environmental Protection Agency, Office of Air and Radiation, Indoor Environments Division, Washington, D.C. EPA 402-K-01-001. March 2001.

Picture 1



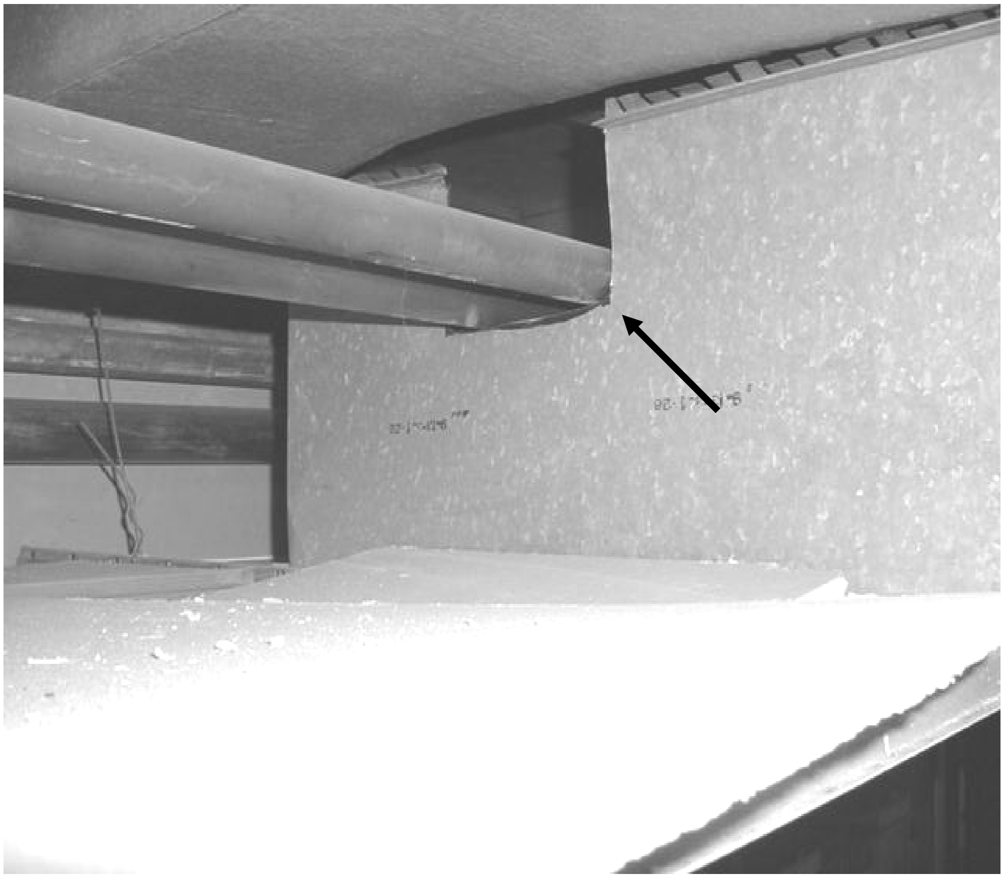
FCU

Picture 2



Transom

Picture 3



Ductwork above City Council Meeting Room, note hole

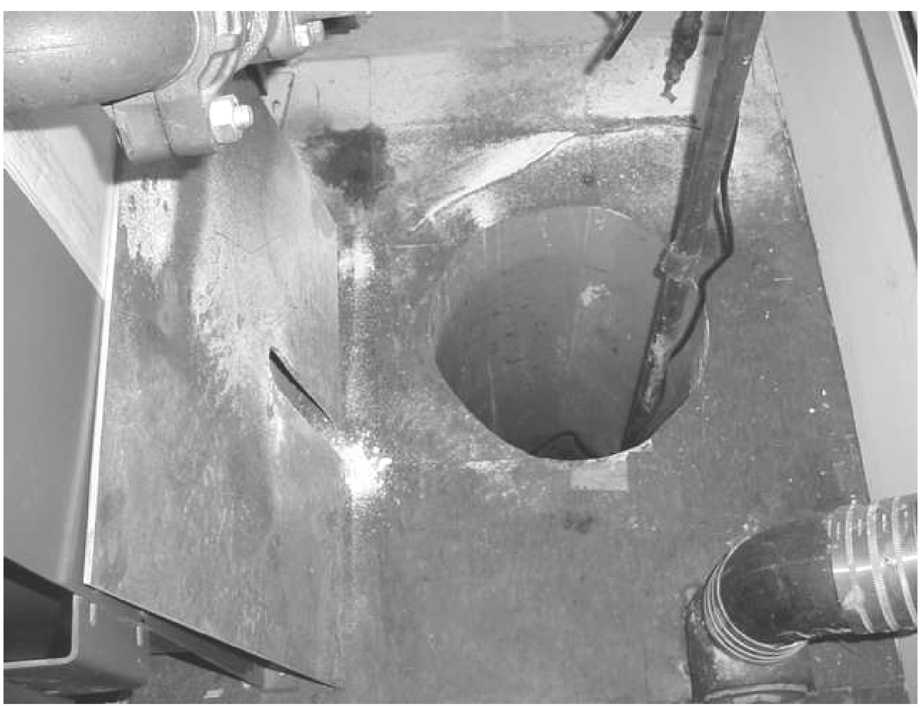
Picture 4

Elevator pressure equalization vent, exterior wall

Picture 5

Elevator pressure equalization vent, elevator shaft wall

Picture 6

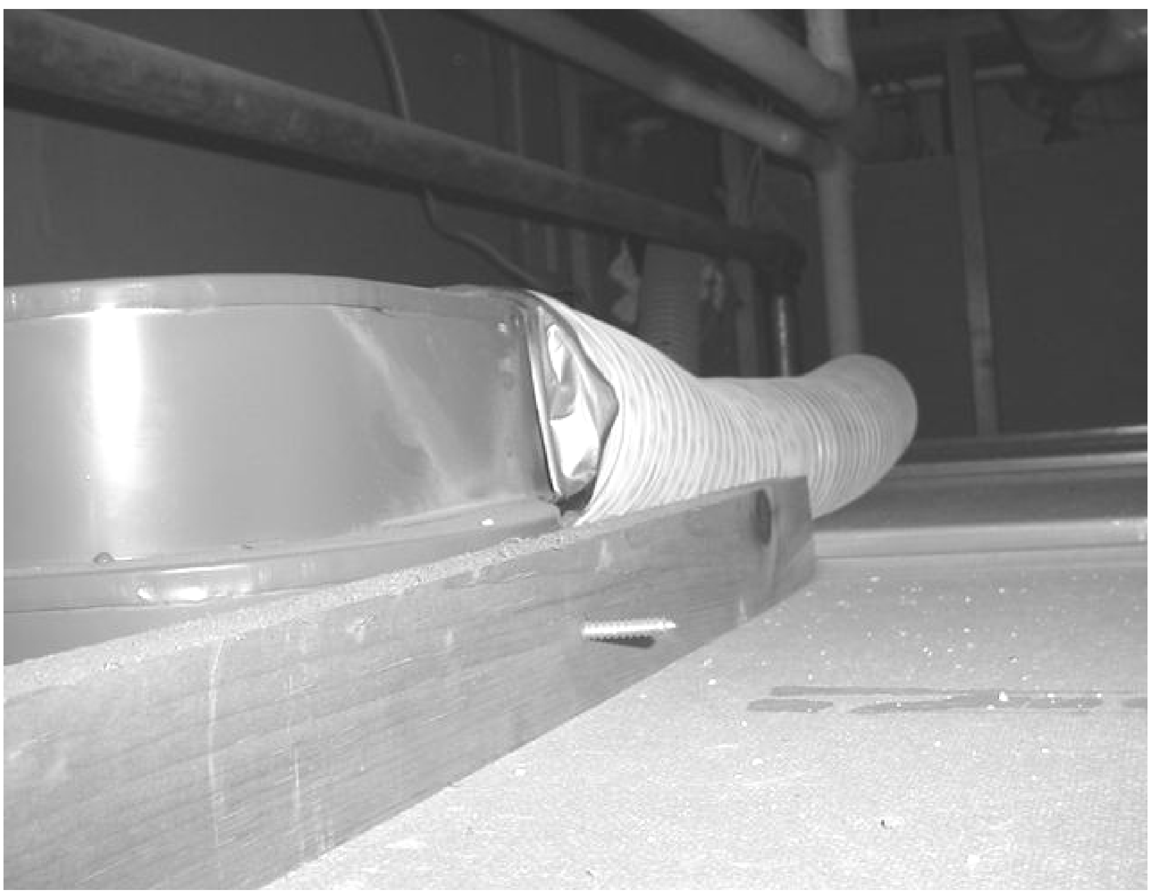


Sump pump, note cover on floor

Picture 7

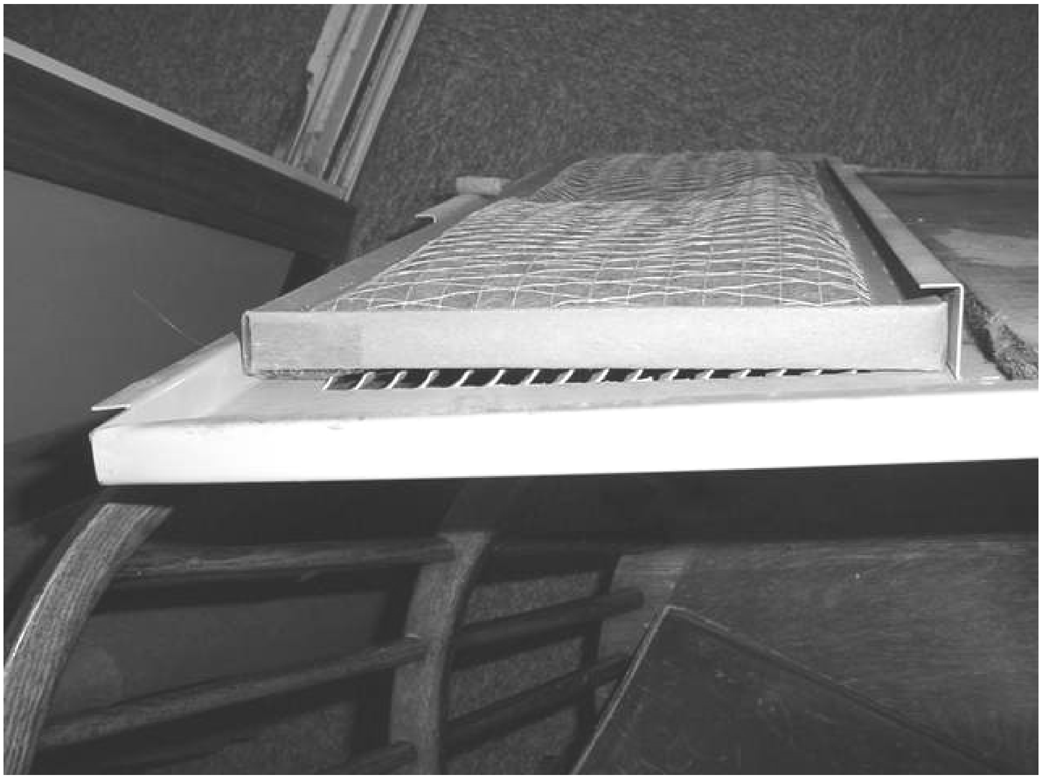
Mold colonized pipe insulation

Picture 8



Hose detached from rest room fan

Picture 9



Undersized filter in FCU

TABLE 1

Indoor Air Test Results
Leominster City Hall, Leominster, MA
April 21, 2006

Location	Carbon Dioxide (*ppm)	Temp (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Outside (Background)	381	68	23					
11 Health Department	827	69	35	1	Y	N	N	FCU Door open
12 Health Department	952	69	35	3	Y	N	N	Moldy bookshelf Door open
12 private office	955	69	36	0	Y	N	N	Perfume odor Door open
10 reception	654	70	31	1	N	N	N	4 water damaged ceiling tiles Door open
10 private office	586	70	33	0	N	N	N	Plants 3 water damaged ceiling tiles Door open
10 private office	589	71	34	0	N	N	N	Door open
10 blueprint room	549	71	34	0	Y	N	N	
10 ticket office	602	71	32	0	Y	N	N	Door open
15	590	70	30	3	Y	N	N	Photocopier Door open

*** ppm = parts per million parts of air**

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

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Location	Carbon Dioxide (*ppm)	Temp (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
City Council Meeting Room	498	69	29	0	Y	Y	Y	Musty odor traceable to elevator shaft Door open
9	640	71	29	1	Y	N	N	Door open
9 inner office	569	73	27	2	Y	N	N	Plants Door open
9 server room	587	73	27	0	Y	N	N	Door open
10 reception	707	74	29	3	Y	N	N	Door open
10 records	688	75	28	0	Y	N	N	Door open
10 private office	728	75	28	1	Y	N	N	Door open
Meeting room	676	74	27	0	Y	N	N	Door open
12	656	73	27	1	Y	N	N	Door open Candle on hot plate
12 private office	671	73	28	1	N	N	N	
Mayor's office reception	571	72	26	1	Y	N	N	

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						Supply	Exhaust	
Mayor's office	543	71	26	0	Y	N	N	1 water damaged ceiling tile
Treasurer reception	708	74	33	2	Y	N	N	Door open
Treasurer	692	74	33	0	Y	N	N	1 water damaged ceiling tile Door open
3	730	73	31	2	Y	N	N	1 water damaged ceiling tile Door open
4	699	74	28	2	Y	N	N	Door open
4 comptroller	791	74	29	1	Y	N	N	Door open
5	567	73	26	2	Y	N	N	Door open
6	682	73	28	1	Y	N	N	Door open

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